AD-A116 594 NAVAL CIVIL ENGINEERING LAB PORT HUENEME CA F/G 13/2
ENERGY DATA MOBILE LABORATORY.(U)
FEB 82 R J TINSLEY, R E BERGMAN
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TECHNICAL NOTE

TN NO: N-1620

TITLE: ENERGY DATA MOBILE LABORATORY

AUTHOR: R. J. Tinsley and R. E. Bergman

DATE: February 1982

SPONSOR: Naval Facilities Engineering Command

PROGRAM NO: Z089-01-621B

NAVAL CIVIL ENGINEERING LABORATORY
PORT HUENEME, CALIFORNIA 93043

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REPORT DOCUMENTATION PAGE

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1 REPORT NUMBER TN-1620	2 GOVT ACCESSION NO. DN987076 AD A116 597	3 RECIPIENT'S CATALOG NUMBER
4 TITLE (and Subtitle) ENERGY DATA MOBILE LABORATORY		5 TYPE OF REPORT & PERIOD COVERED Final: Oct 76 – Sep 81
		6 PERFORMING ORG. REPORT NUMBER
7 AUTHOR(s) R. J. Tinsley and R. E. Bergman		8 CONTRACT OR GRANT NUMBER(s)
9 PERFORMING ORGANIZATION NAME AND ADDRESS NAVAL CIVIL ENGINEERING LABORATORY Port Hueneme, California 93043		10 PROGRAM ELEMENT PROJECT, TASK AREA & WORK UNIT NUMBERS 63724N; Z0829-01-621B
11 CONTROLLING OFFICE NAME AND ADDRESS Naval Facilities Engineering Command Alexandria, Virginia 22332		12 REPORT DATE February 1982
		13 NUMBER OF PAGES 24
14 MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)		15 SECURITY CLASS (of this report) Unclassified
		15a DECLASSIFICATION DOWNGRADING SCHEDULE

16 DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17 DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18 SUPPLEMENTARY NOTES

19 KEY WORDS (Continue on reverse side if necessary and identify by block number)

Energy, data, mobile laboratory, prototype, truck/van, instrumentation, meteorological data, solar collector, photovoltaic array.

20 ABSTRACT (Continue on reverse side if necessary and identify by block number)

The Naval Civil Engineering Laboratory (NCEL) has developed and tested a prototype Energy Data Mobile Laboratory (EDML) housed in a specially designed truck/van. The vehicle tows a trailer-mounted telescoping tower designed for meteorological instrumentation sensors. The prototype EDML provides a secure air conditioned base for flexible energy consumption and environmental measurements. A description and drawings of the EDML

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are provided, and its capabilities, method of operations, instrumentation, testing program and operational potential are discussed.

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Naval Civil Engineering Laboratory
ENERGY DATA MOBILE LABORATORY (Final), by R. J. Tinsley and R. E. Bergman
TN-1620 24 pp illus February 1982 Unclassified

1. Energy monitoring 2. Instrumented van I. Z0829-01-621B

The Naval Civil Engineering Laboratory (NCEL) has developed and tested a prototype Energy Data Mobile Laboratory (EDML) housed in a specially designed truck/van. The vehicle tows a trailer-mounted telescoping tower designed for meteorological instrumentation sensors. The prototype EDML provides a secure air conditioned base for flexible energy consumption and environmental measurements. A description and drawings of the EDML are provided, and its capabilities, method of operations, instrumentation, testing program and operational potential are discussed.

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INTRODUCTION

The Naval Civil Engineering Laboratory (NCEL) has developed and tested a prototype Energy Data Mobile Laboratory (EDML) housed in a specially designed truck/van. Reference 1 provided an overview of the EDML. This Technical Note describes the EDML, outlines its capabilities and method of operation, provides information on testing, and discusses the potential for operational EDMLs. The prototype EDML vehicle was transferred to the Naval Energy and Environmental Support Activity (NEESA) in September 1981.

Requirements

The energy conservation program, along with the mandates to develop alternative sources of energy, creates a demand for detailed and accurate measurement of utility consumption and for collection of meteorological data at Navy shore installations. Every aspect of the search for solutions to the energy problem is dependent upon data that is current and supportable: obtaining optimum utilization of current utilities, determining where to apply concentrated conservation efforts, analyses of alternative systems and sources, feasibility studies of energy monitoring and control systems, and project justifications are examples that require these data.

While measurement of existing utility consumption and demand conditions is of immediate concern to shore activities, the collection of data for the study of alternative energy sources is of longer range importance. Solar energy and wind powered generation systems are currently the dominant alternative sources under investigation. However, until recently there has been no need to collect solar or wind data on a localized basis. Of the 26 National Weather Service SOLMET network stations, only six provide data applicable to Navy shore activities; consequently, there is a need to measure solar radiation. Further, to investigate potential uses of wind powered systems it is necessary to collect wind data at specific sites. Due to surface features and land contours, regional data usually are not adequate.

Given the necessity to collect data on energy utilization and meteorological data, there are requirements to be met to ensure the effort is economical and the data are reliable. Experience in the NCEL Energy Program (Ref 2 and 3) suggests certain criteria for field measurement of energy data:

- Collect the data with the least labor expenditure possible. Since much of the data collection extends over long periods, the system should be designed to be unattended. Automation and remote control quickly pay for themselves in labor savings. A secondary benefit is that the fewer the people involved between the source of measurement and the final user of the data, the less the chance of human error.

- Provide mobility and ease of installation to the measurement package so data may be collected wherever required. A few sets of instrumentation may serve many sites, and labor savings are accrued in connecting and disconnecting instruments.
- Provide uniformity and comparability in utilities measurement throughout the shore establishment. Avoidance of development of instrumentation and methodology by each Engineering Field Division is an additional benefit.

Objectives

The requirements discussed lead to the following overall objectives of the EDML program:

- Develop a cost effective method to measure and collect site specific data on energy consumption, insolation, wind speed and direction, and other meteorological data consistent with the required criteria of minimum labor, maximum mobility, and ease of installation.
- Develop optimum instrumentation packages, configuration design, and a data acquisition system for field use throughout the Naval shore establishment.
- Test the design under actual conditions to demonstrate achievement of the objectives.

The NCEL objective has been to operate and maintain the prototype EDML in furtherance of the above objectives through the collection of energy and meteorological data at sites representing a variety of missions and environments in support of Navy energy R&D programs.

PROTOTYPE EDML

Description

Outfitting and in-service operational testing of the EDML were performed by NCEL. At the completion of the testing, some of the apparatus was removed from the vehicle, and it was transferred to other use. The description in the following paragraphs applies to the intact prototype EDML in operational configuration.

The prototype mobile laboratory was developed around a commercial truck-chassis with a specially designed van (Figures 1 through 10). The interior contains 96 square feet of working space. One inside wall contains a large input-output panel (Figures 4, 5, and 6) into which instrumentation sensors feed for direct measurement of buildings and distribution system utilities consumption and flows. The van interior also houses an electrical power monitor for direct, real-time measurement of consumption, and the equipment necessary for recording and transmitting all data acquired. The equipment is listed in Table 1 and further discussed in following paragraphs.

The vehicle contains an auxiliary battery power supply that is trickle-charged by a roof-mounted photovoltaic array (Figures 2, 4, and 6). This array may be used on the road and as a tilt-up panel on-site. The battery system is capable of providing approximately 12 hours of standby power through two power inverters delivering up to 1500 watts.

A hot water, flat-plate solar collector panel is also mounted on the roof to measure insolation in any attitude from horizontal to vertical (Figures 2, 5, and 8). This collector serves as the source of heat for the van interior through a hot water tank heat exchanger-fan system (Figure 5).

The vehicle tows a trailer-mounted, tilt-up 65-foot telescoping tower. Meteorological data collection instruments are mounted on the tower at the measurement site. The trailer is a Weathermeasure Corporation model 20-CHD with WM-65 tower and roadability equipment. The tower was extensively modified by NCEL. Details are given in Figures 3, 6, 7, 9, and 10.

Instrumentation

There are three basic instruments used to take electric measurements:

- The kilowatt meter will perform two primary functions; measure the amount of power being supplied to the load and the total energy consumed during any time period. Either of these measurements is available at any time. The connection, a clamp-on current transformer, greatly simplifies the installation. Complete monitoring of operation is included with front panel LED warning lamps. It can handle large voltage and current input ranges with no switching necessary. The meter incorporates a battery to provide back-up power that insures data will not be lost if the power is lost.

- Wherever current readings are required, clamp-on ammeters are used. The meter is based on the splitcore transformer principle and raw measurements are processed with micro-miniaturized electronics integrally mounted with the transformer. Direct analog readings are output for input to the datalogger.

- Photoelectric Meter Reader. Watt-hour meters have a marker on the rim of the rotating disk to visually identify power consumption. The photoelectric Meter Reader/Transmitter used with EDML is attached to the glass cover of a meter and "reads" the marker on the disk through interruptions of the constant signal being transmitted. Consumption data is accumulated by a count of the interruptions. The device used to accumulate the output of the Meter Reader is the pulse-to-voltage converter. This instrument is designed with state-of-the-art technology for precision conversion of accumulated pulses into a representative analog voltage. The analog voltage may be displayed on an optional panel meter. The pulse-to-voltage converter is designed to be addressed directly from the address bus of the datalogger.

In addition to the above, Table 1 lists the major instruments and equipment utilized with the prototype EDML; components 1 through 4 are in order of readiness upon set up at a site, components 5 through 10 are in the sequence of information flow from detection to transmission, and item 11 provides processing and control features.

Table 2 provides information on some of the sensor systems utilized.

Capabilities and Operation

The EDML has the capability of obtaining the following data:

- Consumption in major electrical circuits; current and power measurements.
- Temperature and air flow in ducts.
- Steam flow rate.
- Interior temperatures.
- Other types of consumption, flow rates, and temperatures as required to measure energy consumed in space heating and cooling, industrial processes, etc.
- Wind speed and direction.
- Horizontal and latitude insolation.
- Ambient exterior dew point temperature and ambient interior relative humidity.

Sensors and other measurement devices can be connected to energy outlets of several adjacent buildings simultaneously. Data from the sensors, properly conditioned, are fed into a 40-channel datalogger with digital output that interfaces with a tape cassette recorder. The recorder feeds an interactive terminal with a stand-alone, remotely controlled telephone modem that allows the recorded data to be queried by telephone from a compatible terminal, or to be input directly to an on-line computer.

The telescoping tower can be raised to a height of 65 feet without detachment from the vehicle. Wind and other environmental data are read directly into the van. A wind generator simulation system driven by a separate cup anemometer is available to assist in analysis of local wind characteristics.

Testing

The prototype EDML is a research tool for the exploratory development of measurement techniques and evaluation of instrumentation. The design was influenced by the requirements for flexibility and innovation in the comparison of alternative techniques under differing conditions. The mobile laboratory was tested at Naval Air Station, Point Mugu; Naval Station, San Diego; and in the San Francisco Bay area in conjunction with public works organizations at those locations.

The prototype was deployed to Naval Support Activity, Treasure Island, from September 1978 to January 1979. Solar, wind, temperature and humidity data were collected and transmitted from the unattended EDML to NCEL over telephone lines on demand from NCEL. Standby battery charge was maintained by the photovoltaic array which was monitored by the data system. Set up of the van equipment and tower required two people, but take down was accomplished by one person.

Table 3 contains a sample of meteorological data collected. Transient air currents change the direction of wind velocity sensors in between the hourly observations of zero wind speed. The data logger merely reads and records what is there at the time indicated. Humidity of the interior of the EDML was taken because of the assemblage of sensitive electronic instrumentation installed. Exterior dew point measurements were taken also at other times.

From July 1980 to September 1981, the unit was tested at Mare Island Naval Shipyard, Vallejo. The intensity of industrial functions at this activity provided significant electrical measurements which will be the subject of a future Technical Memorandum.

These tests aided in development of measurement techniques, shakedown of the prototype vehicle, and testing of instruments for accuracy, appropriateness and reliability. The basic concepts of the EDML including the automatic, remotely controlled data acquisition system have been demonstrated. Subsequently, the prototype EDML vehicle was transferred to the Naval Energy and Environmental Support Activity in September 1981. NCEL has retained the meteorological tower and trailer in support of the R&D energy program.

OPERATIONAL EDMLs

The prototype vehicle has demonstrated the effectiveness of such vans to support Engineering Field Divisions and Public Works Centers/Departments through flexible, rapid, low cost gathering of energy data. The design resulting from the prototype will:

- Provide labor, time and cost savings by eliminating a large part of the disconnect/reconnect and pack/unpack of instruments with each move from building to building and base to base.
- Eliminate the need for a secure air-conditioned space at each site.
- Provide rapid set up and take down at each site.
- Provide maximum automation from measurement through processing of the data, further reducing personnel time and costs.

Operational Scenario

An operational scenario for either energy consumption and/or meteorological data collection may be as follows:

- Typically the EDML van will be driven from its central location to the site to be monitored for either energy consumption data or meteorological data.
- Once on site the photovoltaic array and the hot water solar collector panel will be activated to provide a secure and temperature-controlled environment.
- If ambient meteorological data is to be monitored, the trailer-mounted telescoping tower with its meteorological instrumentation package will be erected. The interconnecting telemetry cable from the meteorological instruments will plug into the cable receptacle of the van to feed the EDML recording instruments. The operator/technician will then run a test simulation to determine if the meteorological instruments and the EDML recording instruments are all calibrated and functioning correctly. Upon completion of the test, the unit may be placed in automatic mode (if connected to an appropriate telephone line) and secured. If the location is too remote for a telephone tie, the tape storage mode of recording and a scheduled collection of tapes will be implemented.
- If energy consumption data is to be monitored, the voltage and current probes from the EDML will be attached to the primary or secondary side of the transformer feeding the particular facility and the data recorded. To measure steam consumption, steam lines serving the facility must be hot tapped to receive EDML insertion flow meters. Reference 4 discusses this procedure. Normally at an active installation with either a Public Works Center or Department, the installation of the probes would be accomplished by local personnel. All energy consumption connections to the EDML go through an input-output panel.

Drawings of the EDML

Engineering drawings and specifications for the mobile laboratory are included as Figures 2 through 10.

- Figure 2: CEL Drawing 79-5-1F, Energy Data Mobile Laboratory (EDML). This is a right side elevation of the vehicle and housing showing the location of steel reinforcements, trailer hitch, heavy duty bumper, solar (roof) panels and the roof access ladder; all NCEL designed and specified modifications.

- Figure 3: CEL Drawing 79-5-2F, EDML Meteorological Trailer. With orthographic, plan, and right elevation views of the trailer, this drawing depicts the major NCEL modifications to the instrumentation tower/trailer.

- Figure 4: CEL Drawing 79-5-3F, EDML Exterior Plan with Connecting Interior Views. All exterior plan and elevation views and their relation to the general interior layout and furnishings are illustrated.

- Figure 5: CEL Drawing 79-5-4F, EDML Interior Elevations and Plan View. Details and dimensions of the interior cabinet work, chairs, solar hot water heater system, and instrumentation shock mount assemblies are shown.

- Figure 6: CEL Drawing 79-5-5F, EDML Accessories. Dimensions and details of the meteorological spider assembly (for the tower), the exterior view of the connector panel, the solar electric chair, and adapters for the tower tilt and elevating winches are shown.

- Figure 7: CEL Drawing 79-5-6F, Cable Reel Housing. Details and dimensions of the NCEL designed and constructed cable reel housing and mounted winches are shown.

- Figure 8: CEL Drawing 79-5-7F, EDML Solar Panel Support (Water). Dimensions and details of the solar hot water collector panel and associated panel are shown with specifications.

- Figure 9: CEL Drawing 79-5-8F, Modified EDML (Tri-Ex Tower) TR-7 HDO Trailer with 65' Tower. Mast supports, guides, cable sheave, sheave bracket and assembly are depicted with dimensions and specifications.

- Figure 10: CEL Drawing 79-5-9F, EDML Trailer, Reel, Tower Guy Wire. Details and specifications for the guy wire reel and guy wire assemblies are shown.

Costs

Based on the engineering drawings and specifications developed by NCEL, the approximate cost of an EDML is $20,000 for the vehicle plus a minimum of $30,000 for instruments and equipment. NCEL can assist in an analysis of the most cost effective number of vans and their equipment.

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1. Civil Engineering Laboratory. TechData Sheet 78-14: Energy data mobile laboratory. Port Hueneme, Calif., Mar 1978.

2. _____. Technical Memorandum M-53-79-05 (Rev.): Master plan for utilities consumption/demand measurements at Sewell's Point Naval Complex, Norfolk, VA, by R. E. Bergman and R. J. Tinsley. Port Hueneme, Calif., Nov 1979.

3. Naval Civil Engineering Laboratory. Technical Memorandum M-53-81-03: Measurements of winter electrical consumption at Sewell's Point Naval Complex, Norfolk, VA, by R. E. Bergman and R. J. Tinsley. Port Hueneme, Calif., Aug 1981.

4. Civil Engineering Laboratory. Technical Memorandum M-53-79-04: Hot tapping of live steam lines, by R. J. Tinsley. Port Hueneme, Calif., Apr 1979.

Table 1. EDML Instrumentation Function and Testing.

	Major Components	Manufacturer	Function	How Tested	When	Where
1.	Meteorological Instruments	Weathermeasure, Inc.	Accurate measure of energy use environment	Operational; comparison to standard	Apr-Jun 78	CEL, PMTC
2.	Photovoltaic Power System	Spectralabs, Inc.	Charge batteries for back-up power; performance at location.	Operational reliability	May-May 78	CEL
3.	Flat-plate solar heating system	Sunburst, Inc.	Heating of trailer; measure of location.	Operational reliability	May 78	CEL
4.	Instrumentation sensors w/signal conditioning	Various Manufacturers	Generation of electrical signals for measurement.	Operational; Comparison to standard	Apr-Sept 78	CEL, PMTC MCB, NAVSTA
5.	Energy Monitor	Franklin Electric Co. Programmed Power Division	Consumption in major electrical circuits; power budgeting.	Operational; Comparison to standard	May-Jun 78	CEL, PMTC
6.	Data couplers	Fairchild, Inc.	BCD to ASCII Interface	Operational; Implicit	May 78	CEL
7.	Forty-Channel Datalogger	United Systems, Inc.	Analog/digital conversion; data reading at intervals.	Operational; Implicit	May-Jun 78	CEL, PMTC
8.	Incremental digital tape recorder	Techtran, Inc.	Back-up data recording and storage.	Operational reliability	May-Jun 78	CEL, PMTC
9.	Digital terminal (TermniNet)	General Electric Corp.	Transmission of data storage to telephone line.	Operational reliability	May-Jun 78	CEL, PMTC
10.	Telephone communications modem	Ven-Tel Corp.	Link from terminal to telephone line.	Operational reliability	May-Jun 78	CEL, PMTC
11.	Microprocessor, intelligent CRT terminal	Commodore, Inc.	Remote control of components.	Operational	JUL-Sep 78	Remote sites

Table 2. EDML Sensors Systems

Model/Designation	Manufacturer	Function	Range of Sensitivity	Accuracy
METEOROLOGICAL SENSORS:				
1. W-101/Anemometer (propeller)	Weathermeasure Corp.	Wind speed	0-50 mph and 0-100 mph	± 1 mph
W-101 Anemometer (vane)	Weathermeasure Corp.	Wind direction	0-360 degrees	± 1 degree
2. 8-48/Pyranometer (Radiometer)	Eppley, Inc.	Solar radiation (horizontal)	11.41 microvolts/wattmeter^{-2}	$\pm 1\%$
3. 1008/Pyranometer (photovoltaic)	Rho Sigma, Inc.	Solar radiation (latitude)	452 microvolts/wattmeter^{-2}	$\pm 5\%$
4. TP20/Thermistor	Weathermeasure Corp.	Air temperature	-30 to +50^{0}C	$\pm 0.1^0$C
5. 9400/Dew Point	Yellow Springs Instrument Co.	Dew point temperature	-40 to +140^{0}F	$\pm 1^0$F
6. 7682/3 cup sensor (programmable)	Enertech Corp.	Wind Generator Simulation	1 watt to 1 megawatt	$\pm 10\%$
CONSUMPTION SENSORS:				
1. 461-29455/AC transformer	Weston Corp.	AC Current Sensor	0 to 1000 amperes	$\pm 0.05\%$
2. PCE-25X/Transducer	Rochester Instrument, Inc.	Power Sensor	0 to 250 KW	$\pm 1\%$
3. KW 220/Kilowatt Hour Meter	TIF, Inc.	Wattmeter	0 to 100 KW	$\pm 3\%$
4. CT 600 Amp Meter	TIF, Inc.	AC Amp Sensor	0 to 600 Amps	$\pm$ 3%
5. HWA-101/Hot Wire Anemometer	Thermonetics Corp.	Air flow rate in ducts	0.25 to 100 fps	$\pm 1\%$
6. 1035/Steam Flow Sensor	T.F.M. Inc.	Steam flow rate	0 to 100 fps	$\pm 1\%$
7. 103/Thermistor probes	Rho Sigma, Inc.	Solar heater temperature	-32 to +200^{0}F	$\pm 1^0$F
8. 2100 Thermocouple	Sentel Corp.	Interior temperature	-35 to +130^{0}F	$\pm 1^0$F
9. HM111P/Relative Humidity	Weathermeasure Corp.	Interior humidity	0 to 100% R.H.	$\pm 3\%$

Table 3. Sample of Observed Meteorological Data.

Day (May 78)	Hour	Wind Speed	Wind Direction	Interior Relative Humidity	Exterior Temp (^{o}F)	Insolation(Watts/Meter^2) Eppley, Inc (Horizontal)	Rho Sigma, Inc. (Latitude)
14	0600	0 mph	340^{o}	45.1%	60.1	0	4
	0700	0	360	44.8	62.4	38	44
	0800	0	310	46.0	66.4	139	124
	0900	C	300	44.7	66.2	242	272
	1000	0	290	43.4	65.9	272	332
*	1100	3.7	330	39.6	65.7	238	279
*	1200	4.0	330	36.8	64.6	196	228
FOG *	1300	3.5	320	36.4	64.9	215	243
*	1400	4.8	320	35.6	64.7	227	263
	1500	5.4	320	35.3	65.0	417	447
	1600	2.8	320	35.2	64.8	309	347
	1700	3.0	320	33.2	64.9	221	201
	1800	1.4	310	32.6	65.0	128	80
	1900	5.5	320	31.2	63.5	34	31
	2000	4.1	320	34.5	62.3	0	0

Figure 1. Prototype EDML.

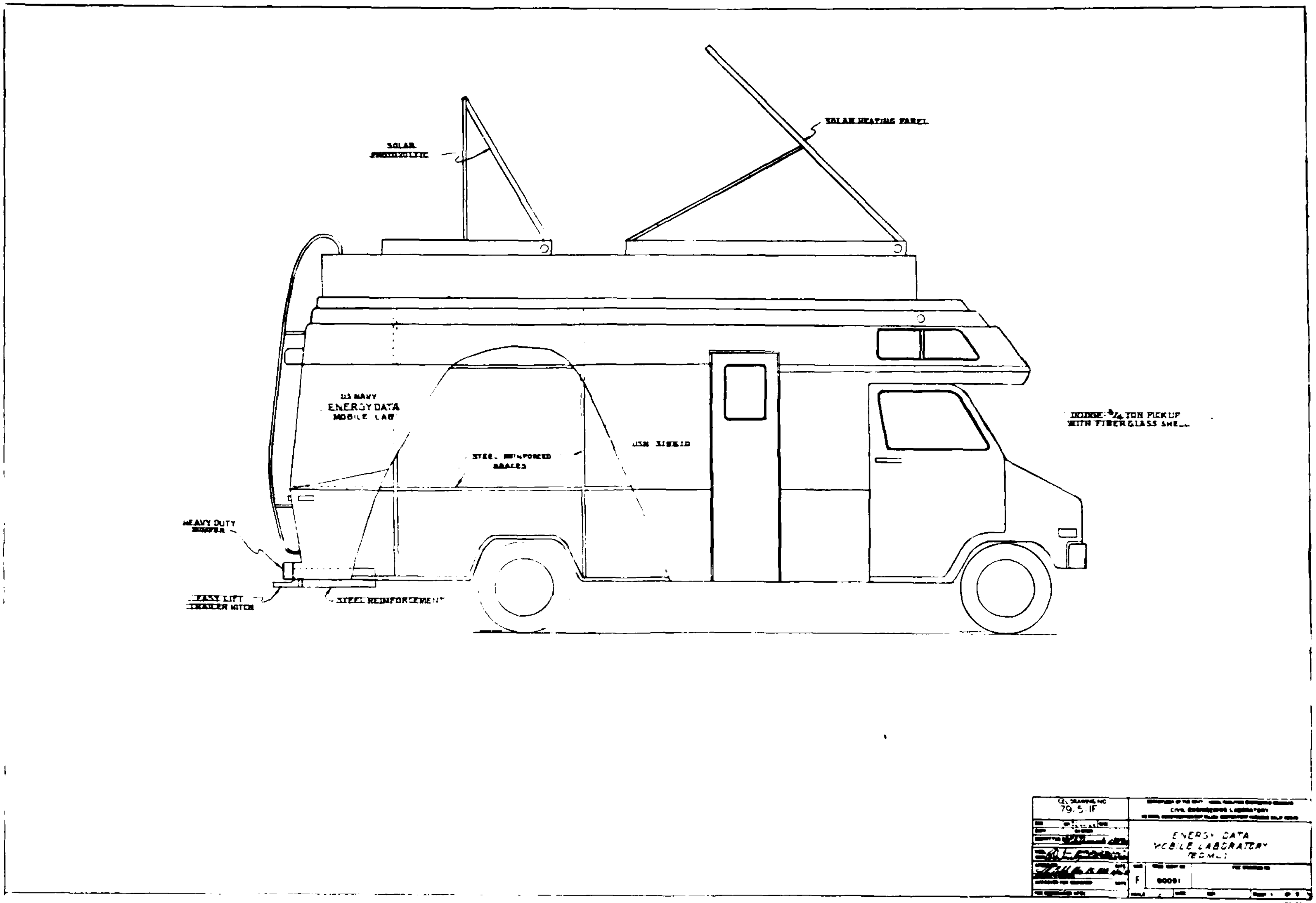

Figure 2. Energy Data Mobile Laboratory (EDML).

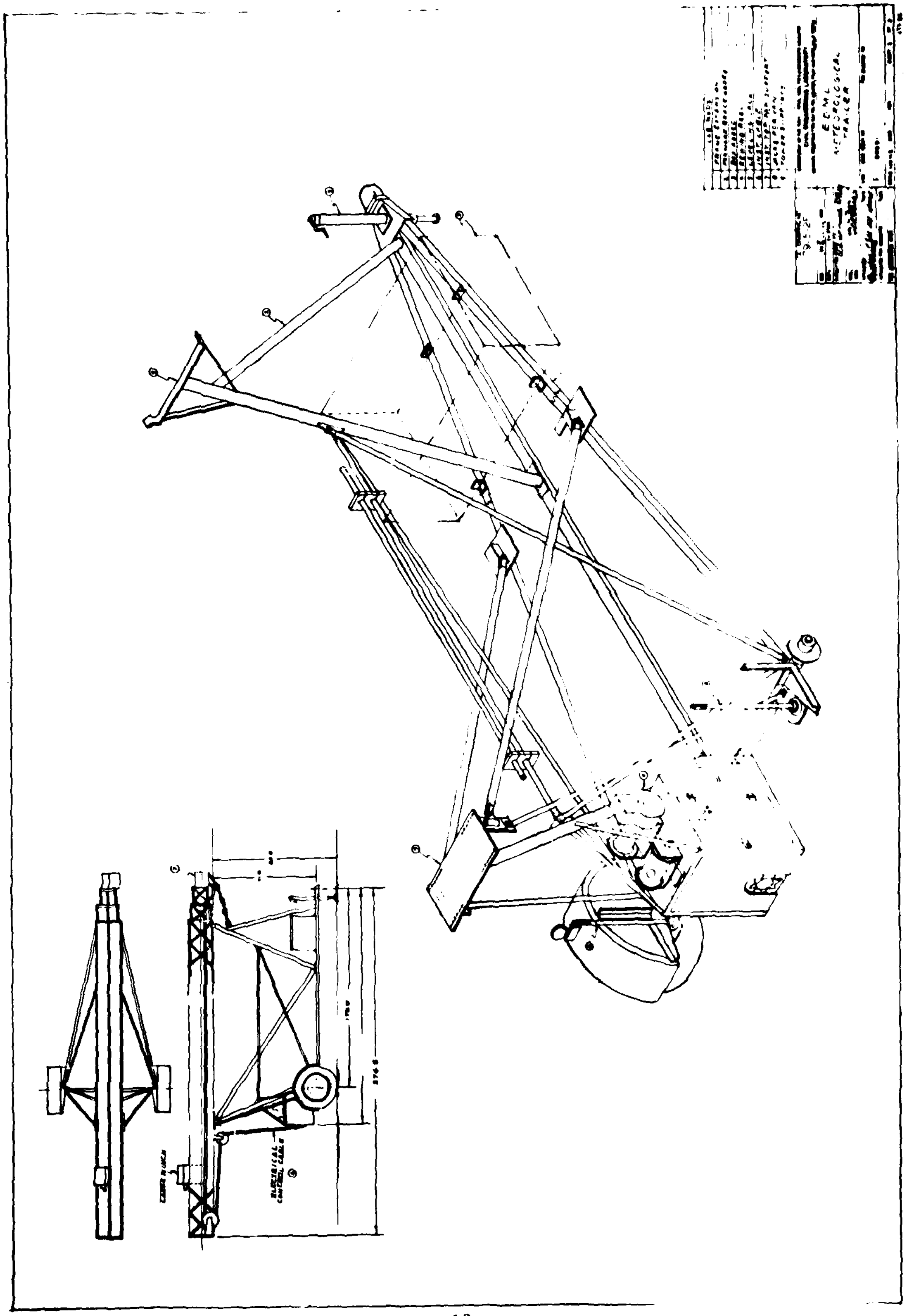

Figure 3. EDML meteorological trailer.

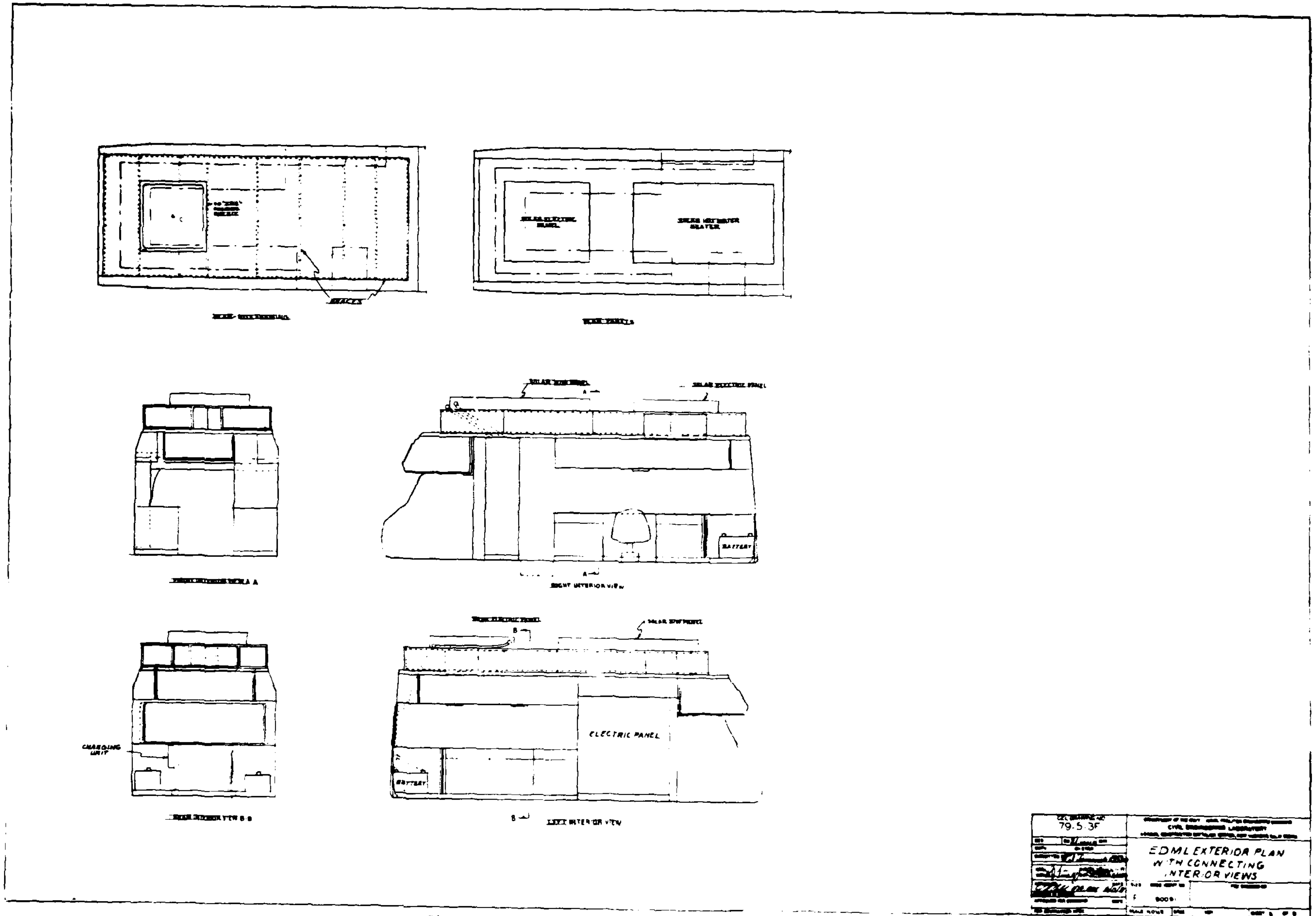

Figure 4. EDML exterior plan with connecting interior views.

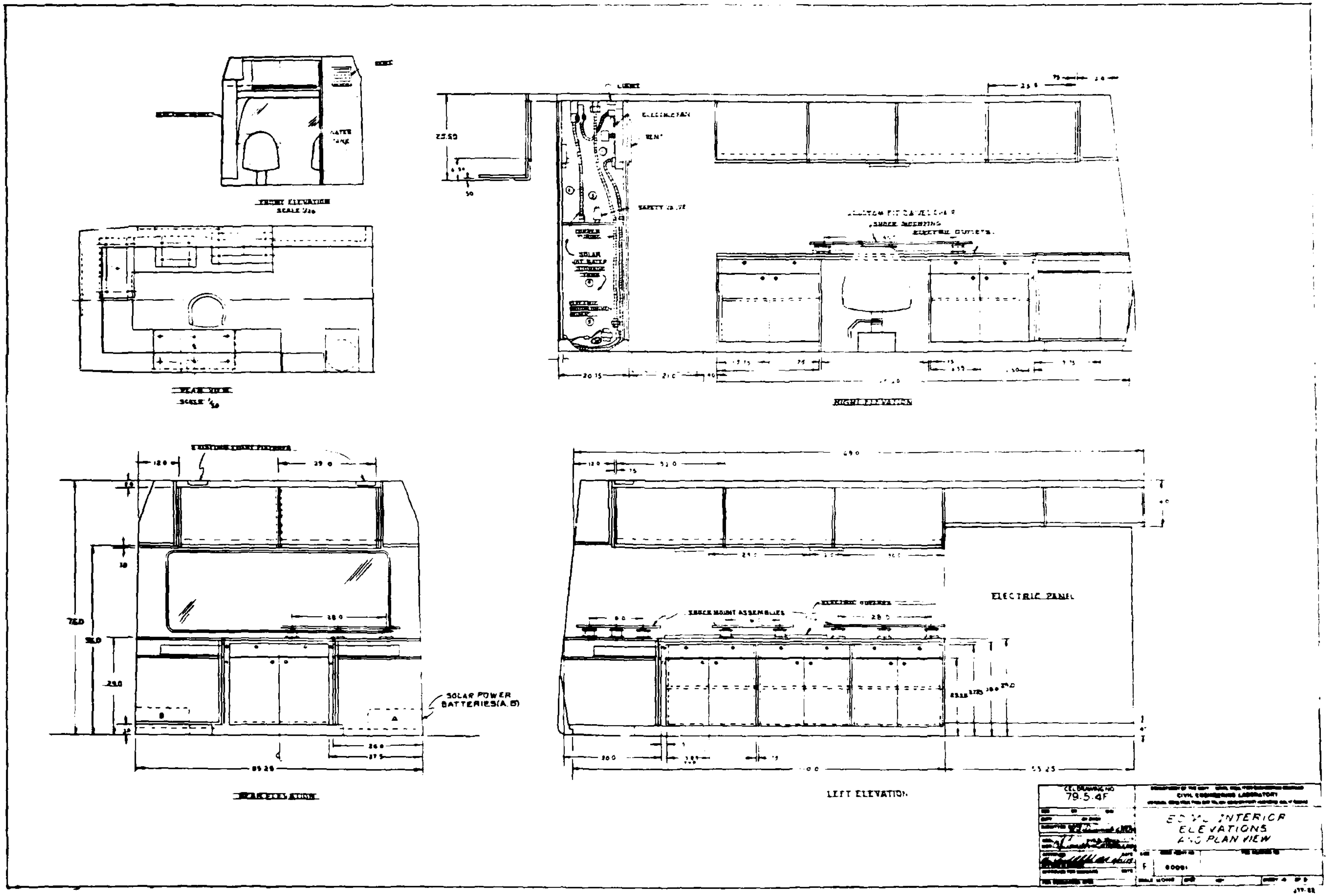

Figure 5. EDML interior elevations and plan view.

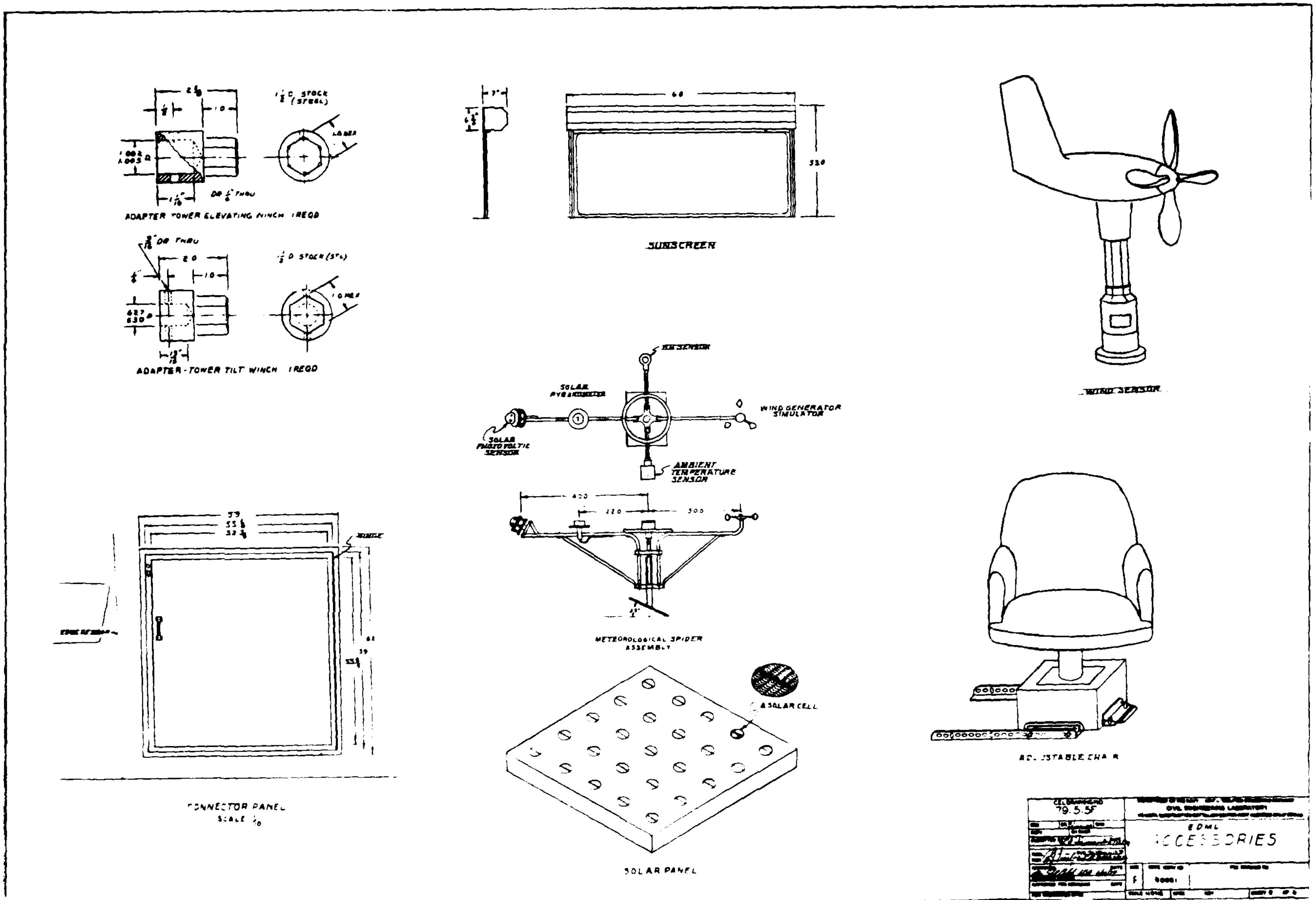

Figure 6. EDML accessories.

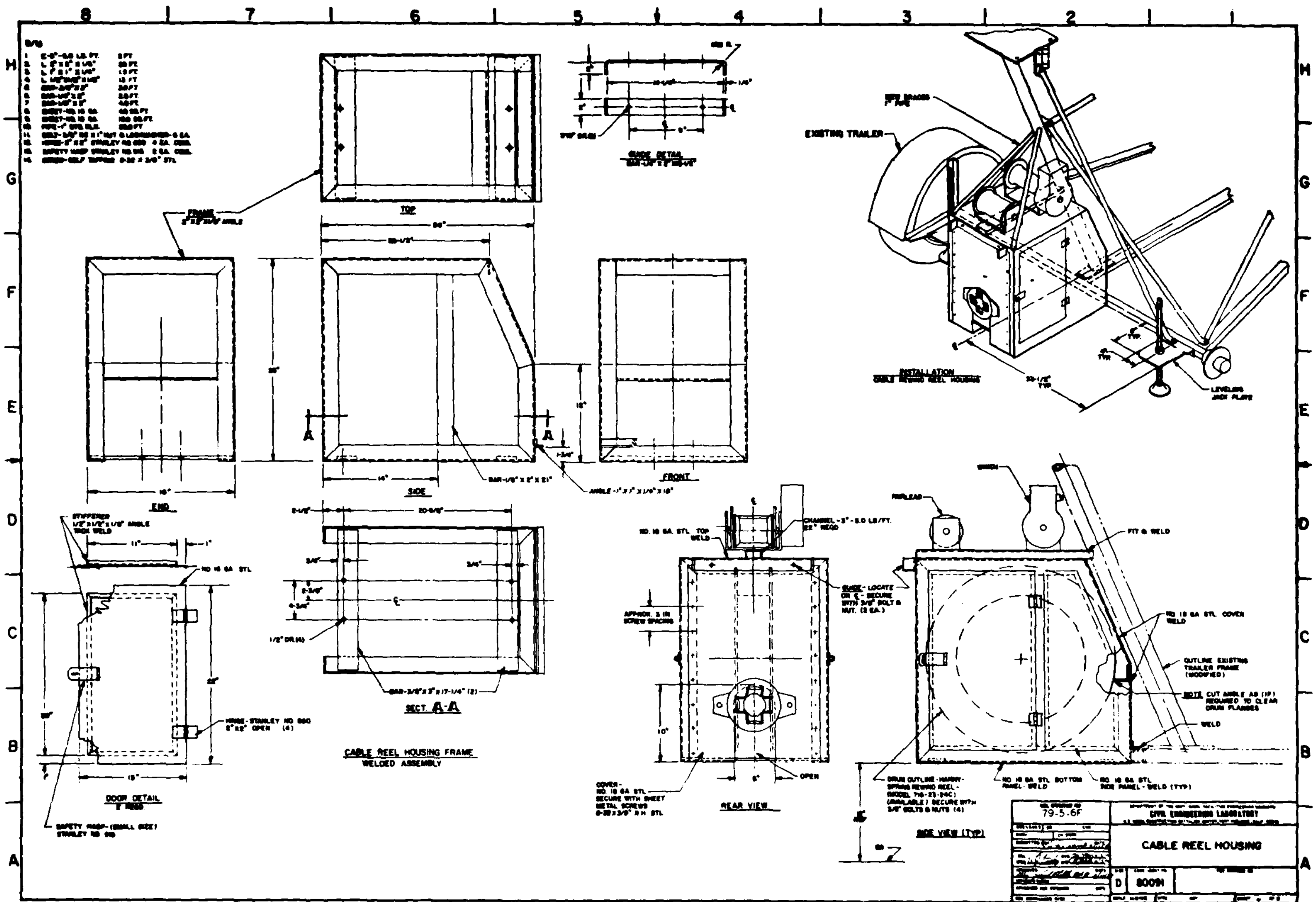

Figure 7. Cable reel housing.

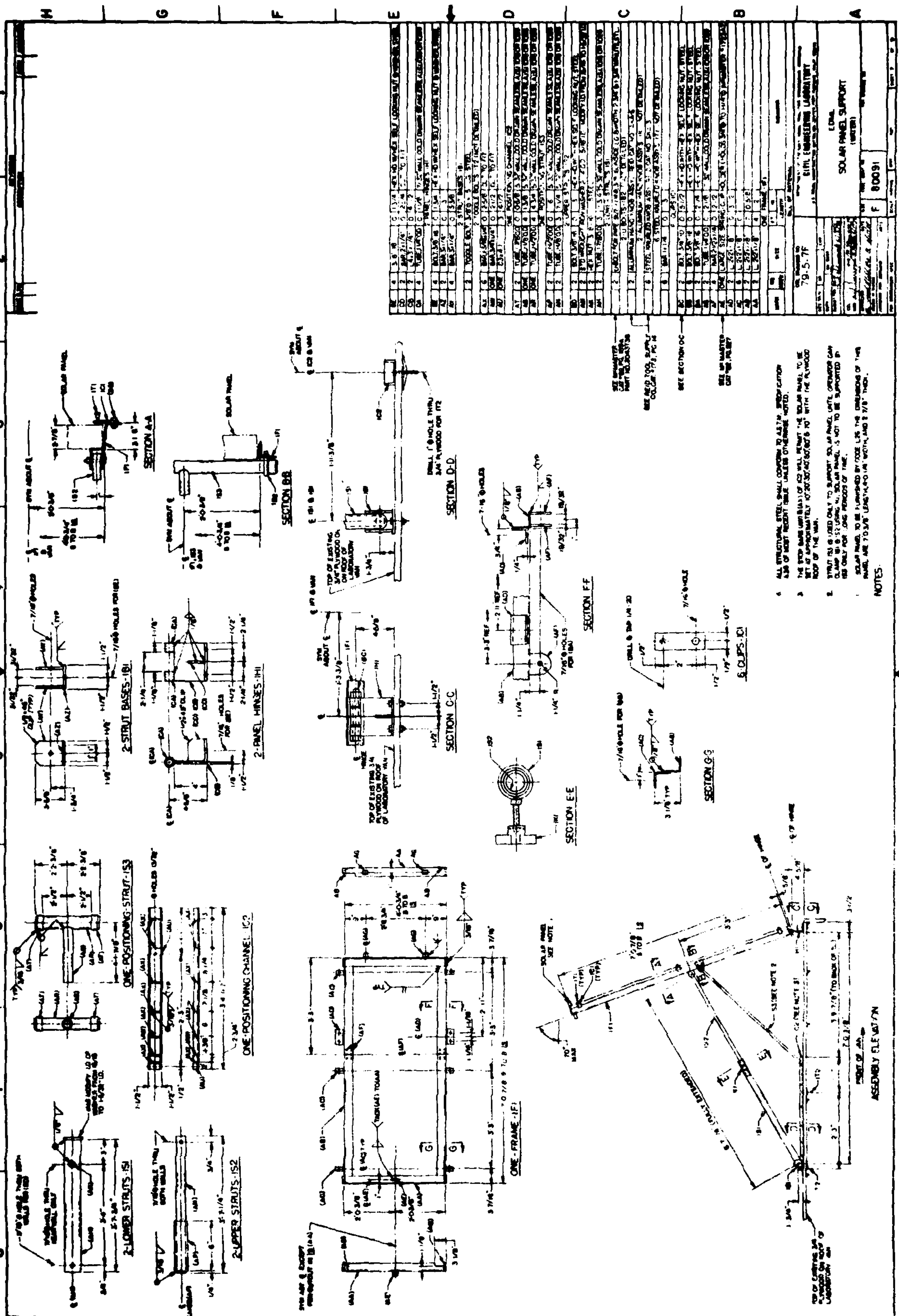

Figure 8. EDML solar panel support (water).

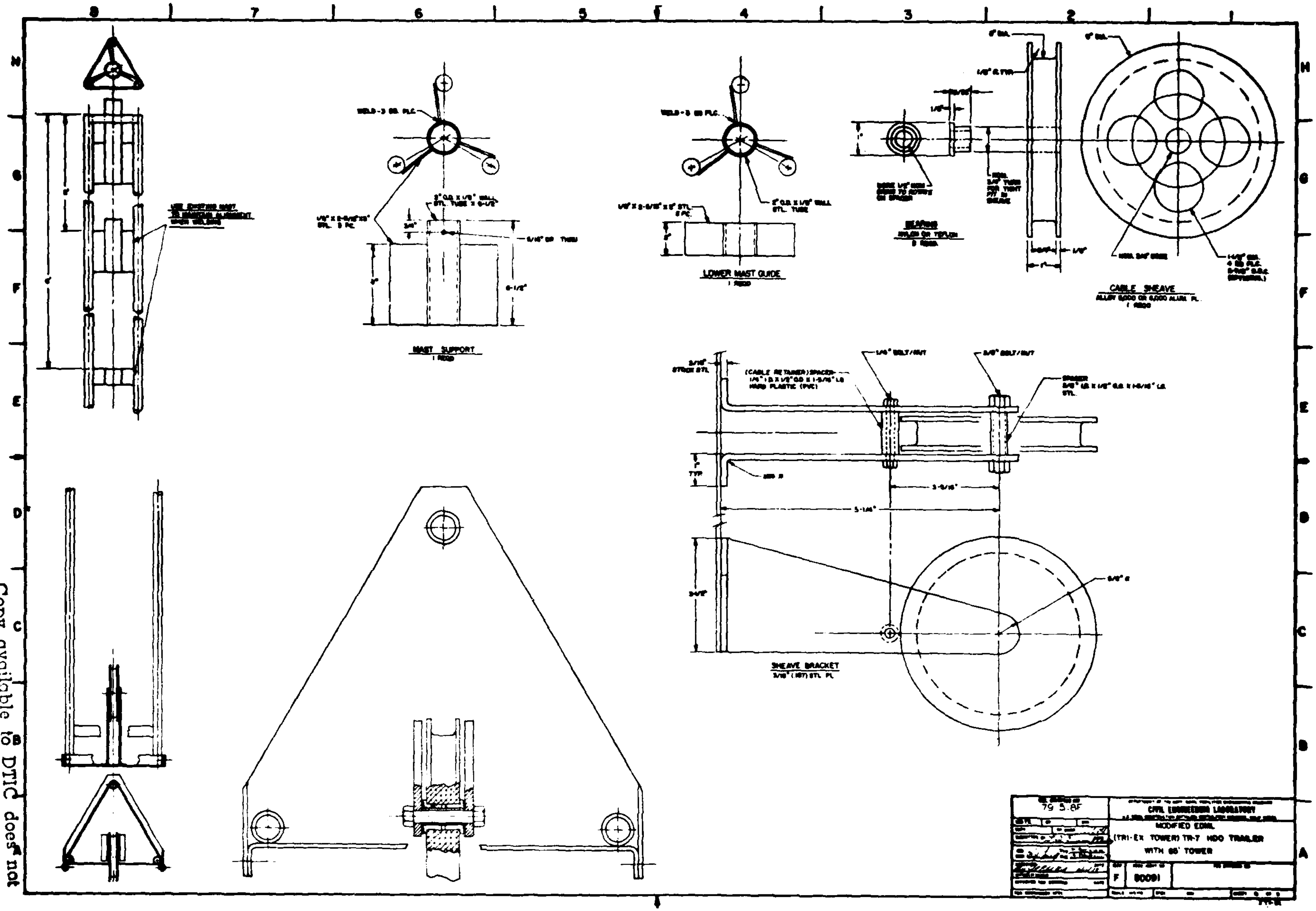

Figure 9. Modified EDML (tri-ex tower) TR-7 HDO trailer with 65-foot tower.

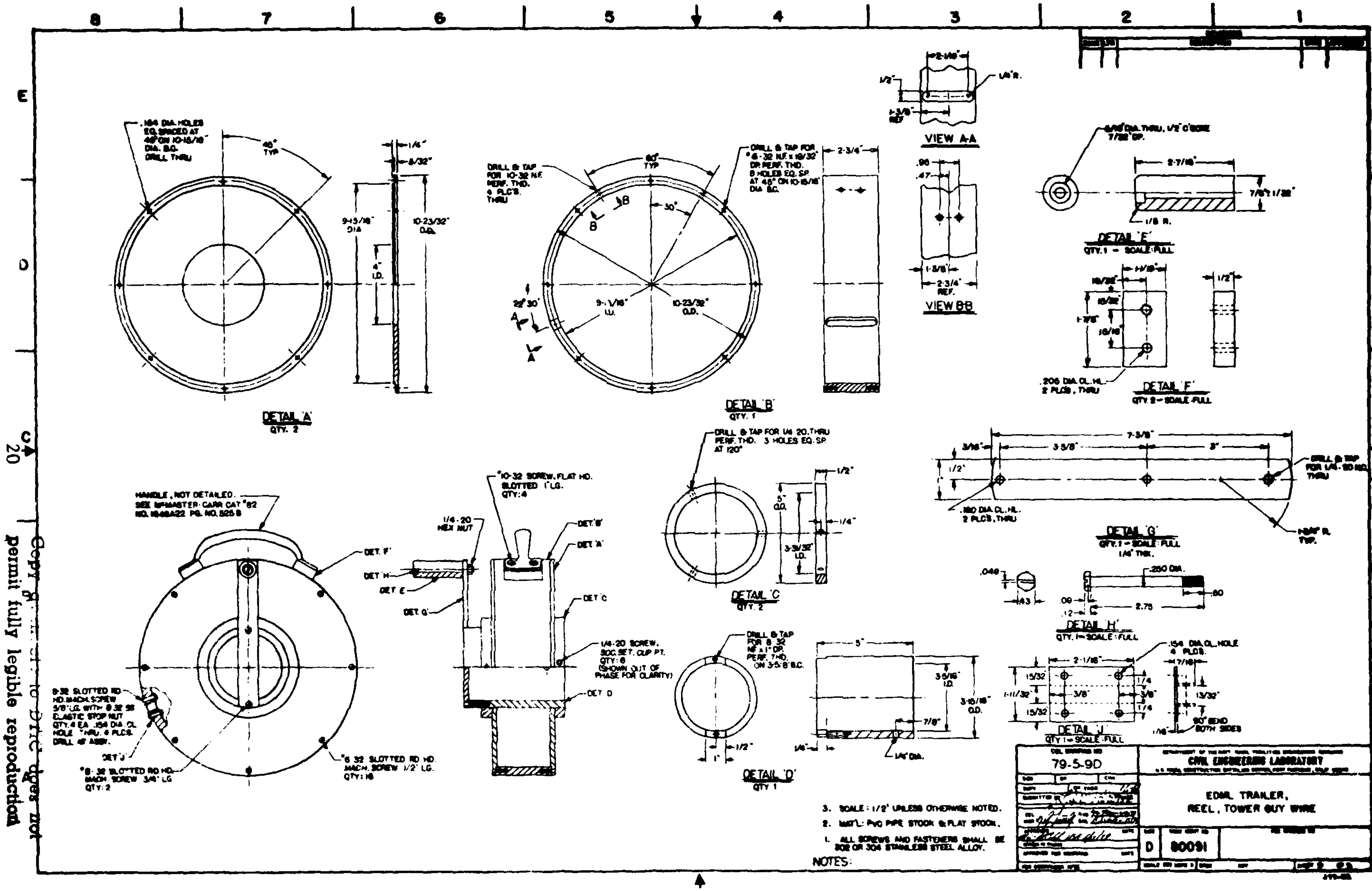

Figure 10. EDML trailer, reel, and tower guy wire.

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MARINE CORPS BASE (L. Hammett) Camp Pendleton, CA; Code 406, Camp Lejeune, NC; PWD - Engr Div, Camp Pendleton, CA; PWD - Maint. Control Div. Camp Butler, Kawasaki, Japan; PWO Camp Lejeune NC; PWO, Camp S. D. Butler, Kawasaki Japan
MARINE CORPS HQS Code LFF-2, Washington DC
MCAS Facil. Engr. Div. Cherry Point NC; CO, Kaneohe Bay HI; Code S4, Quantico VA; Facs Maint Dept - Operations Div, Cherry Point; PWO, Yuma AZ
MCDEC NSAP REP, Quantico VA
MCLB B520, Barstow CA; Maintenance Officer, Barstow, CA; PWO, Barstow CA
MCRD PWO, San Diego Ca
NAF PWD - Engr Div, Atsugi, Japan
NAS PWO Sigonella Sicily
NAF PWO, Atsugi Japan
NALF OINC, San Diego, CA
NARF Code 100, Cherry Point, NC; Code 612, Jax, FL; Code 640, Pensacola FL
NAS CO, Guantanamo Bay Cuba; Code 114, Alameda CA; Code 183 (Fac. Plan BR MGR); Code 18700, Brunswick ME; Code 18U (ENS P.J. Hickey), Corpus Christi TX; Code 8E, Patuxent Riv., MD; Dir. Util. Div., Bermuda; Grover, PWD, Patuxent River, MD; Lakehurst, NJ; Lead. Chief. Petty Offr. PW/Self Help

Div. Beeville TX; PW (J. Maguire), Corpus Christi TX; PWD - Engr Div Dir, Millington, TN, PWD - Engr Div, Oak Harbor, WA, PWD Maint. Cont. Dir., Fallon NV; PWD Maint. Div., New Orleans, Belle Chasse LA; PWD, Maintenance Control Dir., Bermuda; PWO Belle Chasse, LA, PWO Chase Field Beeville, TX, PWO Key West FL, PWO Whiting Fld, Milton FL; PWO, Cubi Point, R.P., PWO, Dallas TX; PWO, Glenview IL; PWO, Millington TN; PWO, Miramar, San Diego CA; ROICC Key West FL; SCE Norfolk, VA; SCE, Barbers Point HI

NASDC-WDC T. Fry, Manassas VA

NATL RESEARCH COUNCIL Naval Studies Board, Washington DC

NAVACT PWO, London UK

NAVAEROSPREGMEDCEN SCE, Pensacola FL

NAVAIRDEVCEN Chmielewski, Warminster, PA; PWD, Engr Div Mgr, Warminster, PA, PWO Warminster, PA

NAVAIRPROPTESTCEN CO, Trenton, NJ

NAVCOASTSYSTCTR CO, Panama City FL; Code 715 (J Quirk) Panama City, FL; Library Panama City, FL

NAVCOMMAREAMSTRSTA SCE, Wahiawa HI; SCE Unit 1 Naples Italy

NAVCOMMSTA CO (61E) Puerto Rico; Code 401 Nea Makri, Greece; PWD-ENG Div Dir Washington, DC; PWO, Fort Amador Panama Canal

NAVCONSTRACEN Curriculum Instr. Stds Offr, Gulfport MS

NAVEDTRAPRODEVCEN Technical Library, Pensacola, FL

NAVEDUTRACEN Engr Dept (Code 42) Newport, RI

NAVEODFAC Code 605, Indian Head MD

NAVFAC PWO, Brawdy Wales UK; PWO, Cape Hatteras, Buxton NC; PWO, Centerville Bch, Ferndale CA; PWO, Guam

NAVFAC PWO, Lewes DE

NAVFAC PWO, Point Sur, Big Sur CA

NAVFACENGCOM Code 032 (Essoglou) Alexandria, VA; Code 043 Alexandria, VA; Code 044 Alexandria, VA; Code 04B3 Alexandria, VA; Code 1113 (T. Stevens) Alexandria, VA, Morrison Yap, Caroline Is.; code 08T Alexandria, VA

NAVFACENGCOM - CHES DIV. Code 112 Washington, DC; Code 403 Washington DC; FPO-1 Washington, DC

NAVFACENGCOM - LANT DIV. CDR E. Peltier; Code 111, Norfolk, VA; Eur. BR Deputy Dir, Naples Italy; J.M. Woodruff, Norfolk, VA; RDT&ELO 102, Norfolk VA

NAVFACENGCOM - NORTH DIV. Code 04 Philadelphia, PA, Code 09P Philadelphia PA; Code 1028, RDT&ELO, Philadelphia PA; Code 111 Philadelphia, PA; ROICC, Contracts, Crane IN

NAVFACENGCOM - PAC DIV. (Kyi) Code 101, Pearl Harbor, HI; CODE 09P PEARL HARBOR HI; Code 402, RDT&E, Pearl Harbor HI; Commander, Pearl Harbor, HI

NAVFACENGCOM - SOUTH DIV. Code 403, Gaddy, Charleston, SC; Code 90, RDT&ELO, Charleston SC

NAVFACENGCOM - WEST DIV. AROICC, Contracts, Twentynine Palms CA, Code 04B San Bruno, CA, O9P/20 San Bruno, CA; RDT&ELO Code 2011 San Bruno, CA

NAVFACENGCOM CONTRACT AROICC, NAVSTA Brooklyn, NY, AROICC, Quantico, VA. Dir, Eng. Div., Exmouth, Australia; Eng Div dir, Southwest Pac, Manila, PI; Virginia Beach, VA; OICC, Southwest Pac, Manila, PI; OICC/ROICC, Balboa Panama Canal; ROICC AF Guam, ROICC, Keflavik, Iceland, ROICC, NAS, Corpus Christi, TX, ROICC, Pacific, San Bruno CA

NAVMAG SCE, Subic Bay, R.P.

NAVOCEANSYSCEN Code 4473B (Tech Lib) San Diego, CA; Code 523 (Hurley), San Diego, CA; Code 6700, San Diego, CA; Code 811 San Diego, CA

NAVORDMISTESTFAC PWD - Engr Dir, White Sands, NM

NAVORDSTA PWO, Louisville KY

NAVPETOFF Code 30, Alexandria VA

NAVPETRES Director, Washington DC

NAVPHIBASE CO, ACB 2 Norfolk, VA; Code S3T, Norfolk VA; SCE, Coronado, San Diego CA

NAVREGMEDCEN PWD - Engr Div, Camp Lejeune, NC; PWO Newport RI

NAVREGMEDCEN PWO, Okinawa, Japan

NAVREGMEDCEN SCE (D. Kaye); SCE San Diego, CA; SCE, Camp Pendleton CA; SCE, Guam; SCE, Oakland CA

NAVREGMEDCEN SCE, Yokosuka, Japan

NAVSCOLCECOFF C35 Port Hueneme, CA

NAVSCSOL PWO, Athens GA

NAVSEASYSCOM SEA 04E (L Kess) Washington, DC
NAVSECGRUACT PWO, Edzell Scotland, PWO, Puerto Rico; PWO, Torri Sta, Okinawa
NAVSHIPYD Code 202.4, Long Beach CA, Code 202.5 (Library) Puget Sound, Bremerton WA; Code 380, Portsmouth, VA; Code 382.3 (R. Law) Pearl Harbor, HI; Code 400, Puget Sound, Code 440 Portsmouth NH, Code 440, Norfolk, Code 440, Puget Sound, Bremerton WA; Code 450, Charleston SC, Code 453 (Util Supr), Vallejo CA; Library, Portsmouth NH, PW Dept, Long Beach, CA; PWO, Mare Is., PWO Puget Sound
NAVSTA Adak, AK, Dir Engr Div, PWD, Mayport FL; CO, Brooklyn NY, Code 4, 12 Marine Corps Dist, Treasure Is., San Francisco CA, Engr Dir., Rota Spain; Long Beach, CA; Maint. Div. Dir Code 531 Rodman Panama Canal; PWD - Engr Dept, Adak, AK; PWD - Engr Div, Midway Is.; PWO Pearl Harbor, HI; PWO, Keflavik Iceland; PWO, Mayport FL; ROICC, Rota Spain, SCE, Guam; SCE, San Diego CA
NAVSUBASE ENS S. Dove, Groton, CT
NAVSUPPACT CO, Naples, Italy; PWO Naples Italy; PWO, Seattle, WA
NAVSUPPFAC PWD - Maint. Control Div, Thurmont, MD
NAVSURFWPNCEN PWO, White Oak, Silver Spring, MD
NAVTECHTRACEN SCE, Pensacola FL
NAVTELCOMMCOM Code 53, Washington, DC
NAVUSEAWARENGSTA Keyport, WA
NAVWPNCEN Code 2636 (W. Bonner), China Lake CA; Code 3803 China Lake, CA; PWO (Code 266) China Lake, CA; ROICC (Code 702), China Lake CA
NAVWPNSTA (Clebak) Colts Neck, NJ; Code 092A (C. Fredericks) Seal Beach CA
NAVWPNSTA PW Office Yorktown, VA
NAVWPNSTA PWD - Maint. Control Div., Concord, CA; PWD - Supr Gen Engr, Seal Beach, CA; PWO, Charleston, SC; PWO, Seal Beach CA
NAVWPNSUPPCEN Code 09 Crane IN
NCTC Const. Elec. School, Port Hueneme, CA
NCBC Code 10 Davisville, RI; Code 15, Port Hueneme CA; Code 155, Port Hueneme CA; Code 156, Port Hueneme, CA; Code 25111 Port Hueneme, CA; Code 430 (PW Engrng) Gulfport, MS; NEESA Code 252 (P Winters) Port Hueneme, CA; PWO (Code 80) Port Hueneme, CA; PWO, Davisville RI
NMCB FIVE Operations Dept; THREE, Operations Off.
NOAA Library Rockville, MD
NRL Code 5800 Washington, DC
NSC Code 54.1 Norfolk, VA
NSD SCE Subic Bay, R.P.
NSWSES Code 0150 Port Hueneme, CA
NUSC Code 131 New London, CT; Code EA123 (R.S. Munn), New London CT; Code SB 331 (Brown), Newport RI
OFFICE SECRETARY OF DEFENSE OASD (MRA&L) Dir. of Energy, Pentagon, Washington, DC
ONR (Scientific Dir) Pasadena, CA; Code 221, Arlington VA; Code 700F Arlington VA
PACMISRANFAC HI Area Bkg Sands, PWO Kekaha, Kauai, HI
PHIBCB 1 P&E, San Diego, CA
PMTC Pat. Counsel, Point Mugu CA
PWC CO Norfolk, VA; CO, (Code 10), Oakland, CA; CO, Great Lakes IL; CO, Pearl Harbor HI; Code 10, Great Lakes, IL; Code 105 Oakland, CA; Code 110, Oakland, CA; Code 120, Oakland CA; Code 120C, (Library) San Diego, CA, Code 154, Great Lakes, IL; Code 200, Great Lakes IL; Code 422, Norfolk, VA; Code 30C, Norfolk, VA; Code 30C, San Diego, CA; Code 400, Great Lakes, IL; Commanding Officer, Subic Bay; Code 400, Pearl Harbor, HI; Code 400, San Diego, CA; Code 420, Great Lakes, IL; Code 420, Oakland, CA; Code 505A (H. Wheeler); Code 600 (Utilities Dept) Norfolk, VA; Code 600, Great Lakes, IL; Code 601, Oakland, CA; Code 700, Great Lakes, IL; Util Dept (R Pascua) Pearl Harbor, HI
SPCC PWO (Code 120) Mechanicsburg PA
TVA Solar Group, Arnold, Knoxville, TN
USAF REGIONAL HOSPITAL Fairchild AFB, WA
USCG (Smith), Washington, DC; G-MMT-4/82 (J Spencer)
USCG R&D CENTER Tech. Dir. Groton, CT
USDA Forest Service Reg 3 (R. Brown) Albuquerque, NM
USNA Ch. Mech. Engr. Dept Annapolis MD; Energy-Environ Study Grp, Annapolis, MD; Environ. Prot. R&D Prog. (J. Williams), Annapolis MD; Mech. Engr. Dept. (C. Wu), Annapolis MD; Ocean Sys. Eng

Dept (Dr. Monney) Annapolis, MD; PWD Engr. Div. (C. Bradford) Annapolis MD
USS FULTON WPNS Rep. Offr (W-3) New York, NY
BROOKHAVEN NATL LAB M. Steinberg, Upton NY
GEORGIA INSTITUTE OF TECHNOLOGY (LT R. Johnson) Atlanta, GA